GEMAC
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User manual

Inclination Sensors with Current and Voltage Interface

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classicLINE

IS1BP360-I-CL
IS2BP090-I-CL
IS1BP360-U-CL
IS2BP090-U-CL

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1 Overview

1.1 Characteristics

- Inclination sensors with measurement range: 360° / ±90° (X/Y)
- Linearized output, high accuracy (0.06°)
- Compensated cross sensitivity
- Programmable vibration suppression
- Freely programmable current or voltage interface
- Robust, UV resistant, impact strength plastic housing
- Suitable for industrial use:
  - Temperature range: -40 °C to +80 °C
  - Degree of protection: IP65/67

The 1-dimensional inclination sensors IS1BP360-I-CL and IS1BP360-U-CL are suitable to measure the inclination in the range of 360°, the 2-dimensional inclination sensors IS2BP090-I-CL and IS2BP090-U-CL are suitable to measure the inclination in 2 dimensions (X/Y) in a range of ±90°. To ensure a high accuracy, the sensors are calibrated at the factory.

The compact and robust design makes the sensor a suitable angle measurement device in rough surroundings for different applications in industry and vehicle technology. A simple setting of all adjustable parameters is possible using the ISPA1 programming adapter.

1.2 Applications

- Solar thermal and photo-voltaic systems
- Agricultural and forestry machinery
- Construction machinery
- Crane and hoisting technology

2 Technical Data IS1BP360-I-CL + IS2BP090-I-CL

General Parameters[1]	IS1BP360-I-CL	IS2BP090-I-CL
Measurement range	360°	±90°
Resolution	0.01°	0.01°
Accuracy	Range 0...360° typical ±0.04° maximum ±0.12°	Range up to ±60° typical ±0.02° maximum ±0.06° up to ±70° ±0.04° ±0.12° up to ±80° ±0.08° ±0.24° up to ±85° ±0.16° ±0.48°
Cross Sensitivity (compensated)	-	typ. ±0.10 %, max. ±0.50 %
Temperature coefficient (zero point)	typ. +0.0088 °/K, -0.0102 °/K	
Sampling rate	100 Hz	
Cut-off frequency	typ. 20 Hz, 2nd order (without digital filter) / 0.1 ... 25 Hz, 8th order (with digital filter)	
Operating temperature	-40 °C to +80 °C	
Characteristics		
Current interface	freely adjustable output in the range 0...20.48 mA (factory default: 4...20 mA) freely adjustable angle in the range 0...360° / ±90°	
Funktionen	Teach input for zero point adjustment when installed Limit value , Axis direction and assignment of the outputs are adjustable Two programmable digital filter (lowpass, 8th order)	
Electrical Parameters		
Supply voltage	17 to 35 VDC	
Current consumption	40 mA @ 24 V + I_{loop}	
Outputs (short-circuit proof)	inductive load less than 1 H, load 500 Ω (default)	
Mechanical Parameters		
Connection	Sensor connector 5-pole M12	
Degree of protection	IP65/67	
Dimensions / Weight	plastic housing: 66 mm x 90 mm x 36 mm / about 200 g	
CE conformity to EC Directive 2006/42/EC		
EC Directives		
RL 2004/108/EC	EMC Directive	
RL 2006/95/EC	Low Voltage Directive (LVD)	
Harmonized standards		
DIN EN 50498:2010	Electromagnetic compatibility (EMC) - Product family standard for aftermarket electronic equipment in vehicles	
EN 60950-1:2006/A1:2010	Information technology equipment. Safety. General requirements	
EN ISO 14982:2009	Agricultural and forestry machinery. Electromagnetic compatibility. Test methods and acceptance criteria	
DIN EN 13309:2010	Construction machinery - Electromagnetic compatibility of machines with internal power supply	

Table 1: Technical Data

1 All indicated angle accuracies are valid after a running time of 10 minutes at 25 °C, Cut-off frequency 0.3 Hz
Absolute calibration accuracy (at 25 °C): ±0.05°

Electromagnetic Compatibility (EMC)			
Transient Emissions			
Radiated disturbance / Radio field strength	Limit curves broadband and narrowband EN ISO 14982 (agricultural and forestry machinery) respectively EN ISO 13309 (construction machinery) 30 ... 1000 MHz (vertical and horizontal)		
Immunity to Radio Frequency Fields (RF fields)			
Strip line according to ISO 11452-5	Limits according to EN ISO 14982 (agricultural and forestry machinery) respectively EN ISO 13309 (construction machinery) 20 ... 400 MHz 200 V/m (1 KHz AM) Performance criteria A		
Anechoic chamber according to ISO 11452-2	Limits according to EN ISO 14982 (agricultural and forestry machinery) respectively EN ISO 13309 (construction machinery) 200 ... 1000 MHz vertical / 400 ... 1000 MHz horizontal 100 V/m (1 KHz AM) Performance criteria A		
Immunity to Conducted Disturbances (on-board power supply 24 VDC)			
Test pulse according to ISO 7637-2:2004	Test pulse 1 -450 V 2a +37 V 2b +20 V 3a -150 V 3b +150 V 4 -12 V 5a +70 V 5b +36 V	Severity level III III III III III III Ri = 1 Ω Ri = 0.5 Ω	Performance criteria C B C A A B A A
Immunity to Electromagnetic Discharge (ESD)			
ESD according to ISO 10605:2008	Limits according to EN ISO 14982 (agricultural and forestry machinery) respectively EN ISO 13309 (construction machinery) discharge combination 330 pF / 330 Ω Contact discharge 8 KV bipolar (metallic parts) Air discharge 15 KV bipolar Performance criteria A		

Table 2: Electromagnetic Compatibility (EMC)

3 Technical Data IS1BP360-U-CL + IS2BP090-U-CL

General Parameters[2]	IS1BP360-U-CL	IS2BP090-U-CL
Measurement range	360°	±90°
Resolution	0.01°	0.01°
Accuracy	Range 0...360° typical ±0.04° maximum ±0.12°	Range up to ±60° typical ±0.02° maximum ±0.06° up to ±70° ±0.04° ±0.12° up to ±80° ±0.08° ±0.24° up to ±85° ±0.16° ±0.48°
Cross Sensitivity (compensated)	-	typ. ±0.10 %, max. ±0.50 %
Temperature coefficient (zero point)	typ. ±0.0083 °/K	
Sampling rate	100 Hz	
Cut-off frequency	typ. 20 Hz, 2nd order (without digital filter) / 0.1 ... 25 Hz, 8th order (with digital filter)	
Operating temperature	-40 °C to +80 °C	
Characteristics		
Voltage interface	freely adjustable output in the range -10.48...10.48 V (factory default: 0...10 V) freely adjustable angle in the range 0...360° / ±90°	
Funktionen	Teach input for zero point adjustment when installed Limit value , Axis direction and assignment of the outputs are adjustable Two programmable digital filter (lowpass, 8th order)	
Electrical Parameters		
Supply voltage	10 to 35 VDC	
Current consumption	55 mA @ 24 V	
Outputs (short-circuit proof)	capacitive load less than 1.2 µF, resistive load greater than 2 kΩ	
Mechanical Parameters		
Connection	Sensor connector 5-pole M12	
Degree of protection	IP65/67	
Dimensions / Weight	plastic housing: 66 mm x 90 mm x 36 mm / about 200 g	
CE conformity to EC Directive 2006/42/EC		
EC Directives		
RL 2004/108/EC	EMC Directive	
RL 2006/95/EC	Low Voltage Directive (LVD)	
Harmonized standards		
DIN EN 50498:2010	Electromagnetic compatibility (EMC) - Product family standard for aftermarket electronic equipment in vehicles	
EN 60950-1:2006/A1:2010	Information technology equipment. Safety. General requirements	
EN ISO 14982:2009	Agricultural and forestry machinery. Electromagnetic compatibility. Test methods and acceptance criteria	
DIN EN 13309:2010	Construction machinery - Electromagnetic compatibility of machines with internal power supply	

Table 3: Technical Data

2 All indicated angle accuracies are valid after a running time of 10 minutes at 25 °C, Cut-off frequency 0.3 Hz
Absolute calibration accuracy (at 25 °C): ±0.05°

Electromagnetic Compatibility (EMC)			
Transient Emissions			
Radiated disturbance / Radio field strength	Limit curves broadband and narrowband EN ISO 14982 (agricultural and forestry machinery) respectively EN ISO 13309 (construction machinery) 30 ... 1000 MHz (vertical and horizontal)		
Immunity to Radio Frequency Fields (RF fields)			
Strip line according to ISO 11452-5	Limits according to EN ISO 14982 (agricultural and forestry machinery) respectively EN ISO 13309 (construction machinery) 20 ... 400 MHz 200 V/m (1 KHz AM) Performance criteria A		
Anechoic chamber according to ISO 11452-2	Limits according to EN ISO 14982 (agricultural and forestry machinery) respectively EN ISO 13309 (construction machinery) 200 ... 1000 MHz vertical / 400 ... 1000 MHz horizontal 100 V/m (1 KHz AM) Performance criteria A		
Immunity to Conducted Disturbances (on-board power supply 24 VDC)			
Test pulse according to ISO 7637-2:2004	Test pulse 1 -450 V 2a +37 V 2b +20 V 3a -150 V 3b +150 V 4 -12 V 5a +70 V 5b +36 V	Severity level III III III III III III Ri = 1 Ω Ri = 0.5 Ω	Performance criteria C B C A A B A A
Immunity to Electromagnetic Discharge (ESD)			
ESD according to ISO 10605:2008	Limits according to EN ISO 14982 (agricultural and forestry machinery) respectively EN ISO 13309 (construction machinery) discharge combination 330 pF / 330 Ω Contact discharge 8 KV bipolar (metallic parts) Air discharge 15 KV bipolar Performance criteria A		

Table 4: Electromagnetic Compatibility (EMC)

4 Mounting

4.1 Position of Drilling Holes

The four drilling holes to mount the sensor (Figure 1) are situated in the base plate of the inclination sensor.

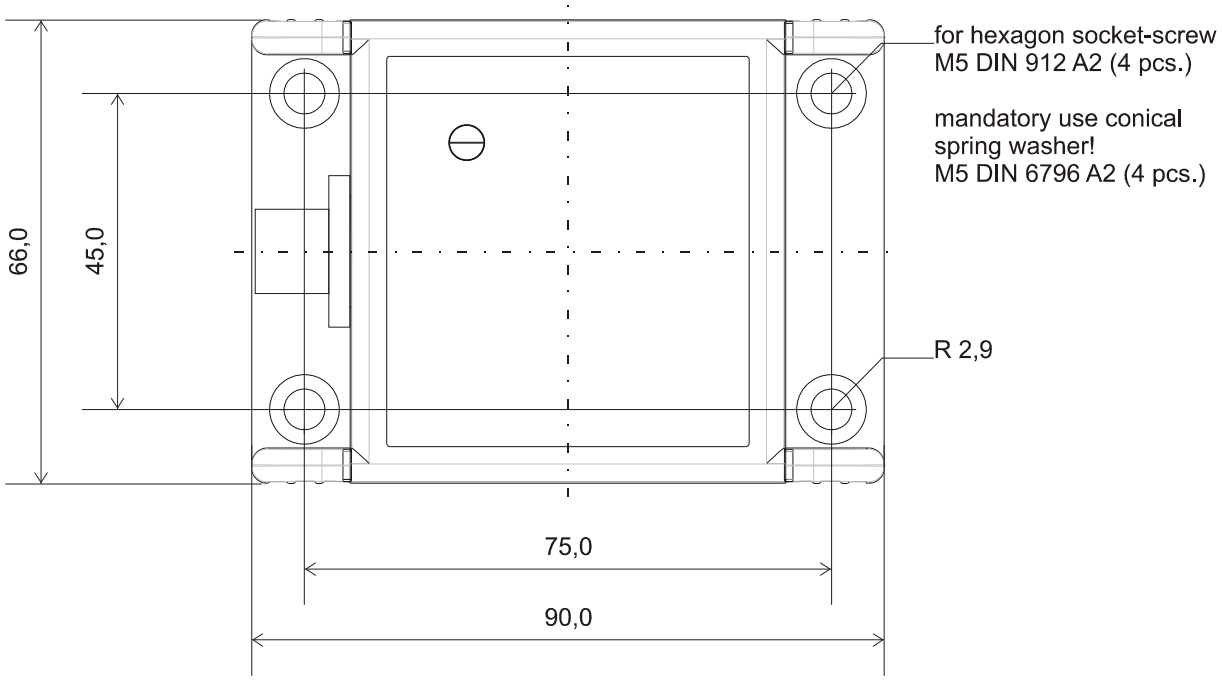


Figure 1: Dimensioned Sketch of plastic housing

4.2 Definition of the Axes

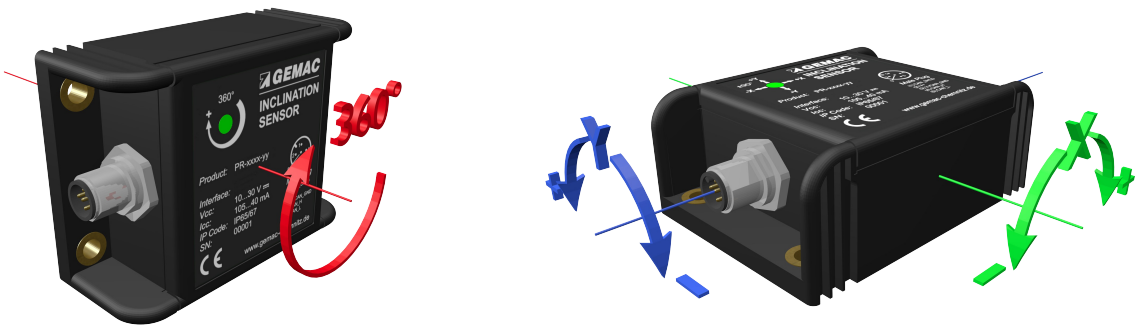


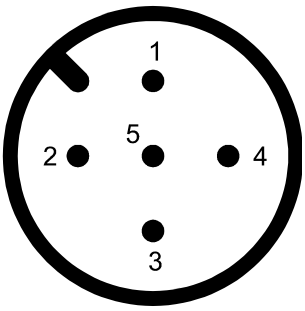
Figure 2: Definition of the Axes (factory default settings)

5 Connection

5.1 Connector Pin Out

The inclination sensors IS1BP360-I-CL, IS2BP090-I-CL, IS1BP360-U-CL and IS2BP090-U-CL are equipped with a common 5-pole round plug M12 (A-coded).

Pin	Signal	Allocation
1	V+	Supply voltage (+24 V)
2	B-OUT (Standard Y)	Sensor output B
3	V- / GND	Supply voltage ground / Sensor ground
4	A-OUT (Standard X)	Sensor output A
5	TEACH	Input for zero point adjustment



(View from the outside)

Figure 3: Connector Pin Out

5.2 Connection diagram

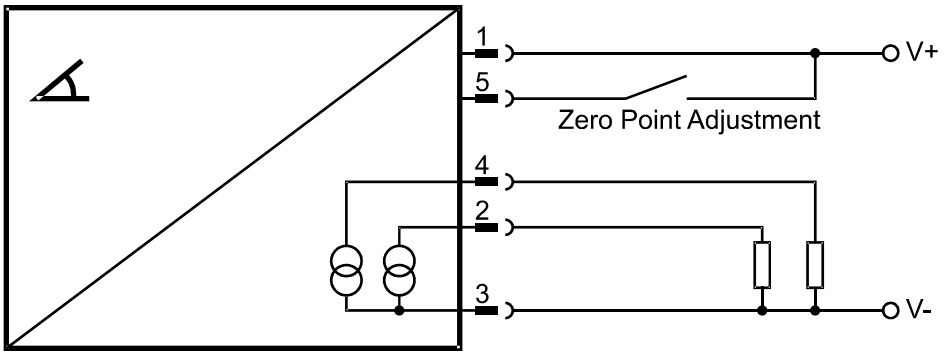


Figure 4: Connection diagram: current interface

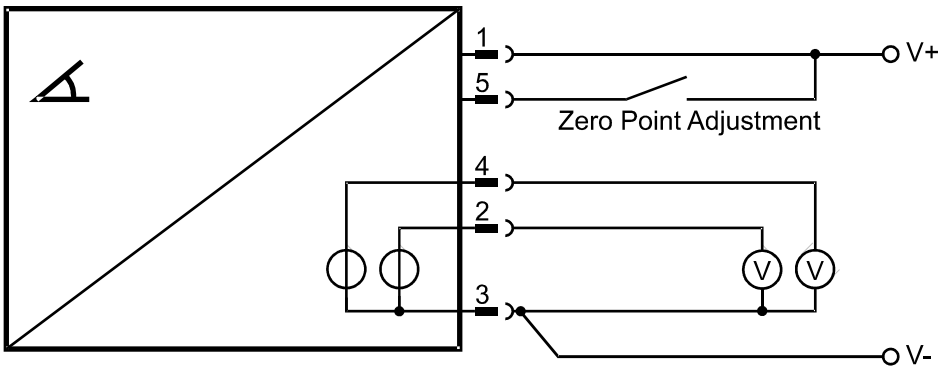


Figure 5: Connection diagram: voltage interface

5.3 Cable length and minimum supply voltage for current interface

At current interface (IS1BP360-I-CL + IS2BP090-I-CL), the required supply voltage is increased by the voltage drop on the connected cable. The highest voltage drop on the cable is produced when the maximum current of 20 mA is flowing through the resistance of the cable (R_L). Here, the resistance of the outgoing and the incoming wire must be taken into account (refer to Figure 6).

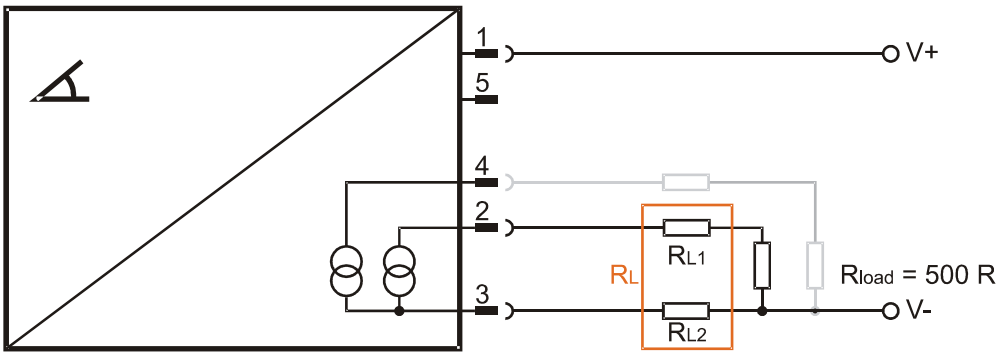


Figure 6: Cable length at current interface

The following table shows examples of the possible cable length at minimum supply voltage and the corresponding wire size (cross section). The table is based on the calculation of the line resistance according to VDE 0295 and a load resistance (R_{load}) of 500 Ω.

Minimum supply voltage in V	Cable resistance in Ω	Maximum cable length in m at wire sizes of:				
		0.14 mm²	0.25 mm²	0.34 mm²	0.50 mm²	0.75 mm²
17	10	35	60	84	124	187
18	50	176	304	423	623	936
20	150	528	914	1271	1870	2808
22	250	880	1524	2118	3117	4681
24	350	1232	2134	2966	4364	6554
26	450	1584	2743	3813	5610	8426
28	550	1936	3353	4661	6857	10299
30	650	2288	3963	5508	8104	12172

Table 5: Cable length at minimum supply voltage and different wires sizes

6 Functional description

6.1 Axis assignment / Axis direction

All inclination sensors ISxBPxxx-I-CL and ISxBPxxx-U-CL have two analog outputs A and B that can be assigned to any in hardware available X and Y axes for the 2-dimensional inclination sensor and to the rotation axis in the 1-dimensional inclination sensor. An assignment of both outputs to the same axis is also possible. With the optional inversion of the axis direction, every conceivable constellation of the output assignment is possible. The axis direction can be changed by swapping the upper and lower current or voltage output values.

6.2 Zero Point Adjustment

For all inclination sensors ISxBPxxx-I-CL and ISxBPxxx-U-CL, the zero point can be adjusted. This allows to set the zero position in the installed state of the sensor. This can either be made via the PC program, by the teach adapter TA1 (PR-23998-00) or by means of the teach input. To set the zero point using the teaching input, it must be connected for a period of at least one second with the supply voltage (V+, pin 1). The current position of the inclination sensor is then set for each output to zero degree angle. The sensor will confirm this by turning off the Status LED for the duration of one second. To reset the zero point to factory defaults, the teaching input has to be connected for the duration of three additional seconds to the supply voltage. The sensor will indicate this by turning off the Status LED for also three seconds.

6.3 Digital Filter

The inclination sensors ISxBPxxx-I-CL and ISxBPxxx-U-CL offers the possibility to suppress the influence of external disturbing vibrations. The internal lowpass digital filters (8th order) are programmable down to 0.1 Hz. The sensor has two digital filters that can be selected according to the application of the sensor.

Filter	Adjustable frequency range	Applications
Butterworth	0.1 Hz ... 25 Hz	Static inclination measurement with high damping to vibration
Critically damped	0.1 Hz ... 8 Hz	Inclination measurement in applications that requires a certain dynamism, without overshoot at angle changes with good damping

Table 6: Filter selection

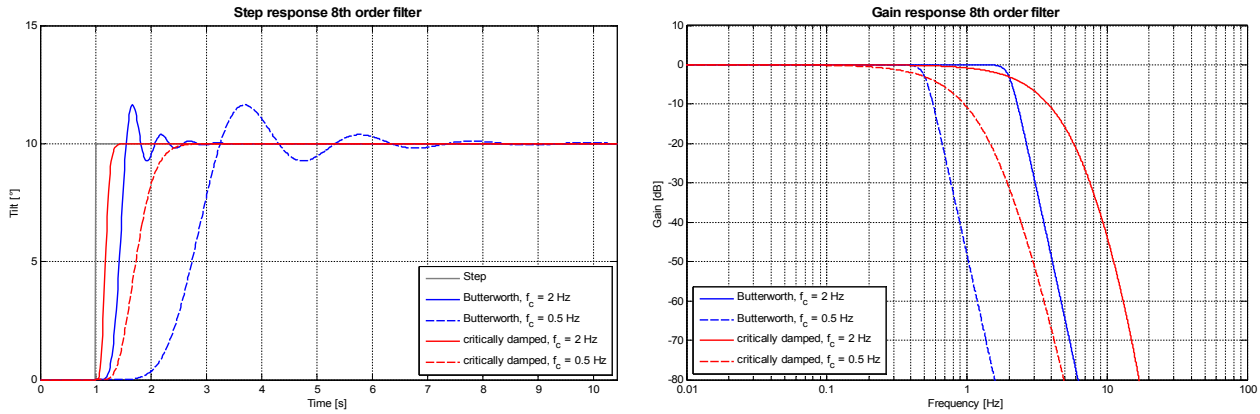

Step response 8th order filter
Tilt [°]
Time [s]
Step
Butterworth, f_c = 2 Hz
Butterworth, f_c = 0.5 Hz
critically damped, f_c = 2 Hz
critically damped, f_c = 0.5 Hz
Gain response 8th order filter
Gain [dB]
Frequency [Hz]
Butterworth, f_c = 2 Hz
Butterworth, f_c = 0.5 Hz
critically damped, f_c = 2 Hz
critically damped, f_c = 0.5 Hz

Figure 7: Impulse and amplitude response of the two filters

6.4 Status LED

The integrated two-color Status LED signals the recent device state. The color of the LED distinguish the different device states as shown in Table 7.

Status LED	Description
Off	No power supply or teach confirmation
Green	The device is in working condition
Red	Current interface: one or both outputs in open circuit condition or wrong connected Voltage interface: one or both outputs in short circuit condition or wrong connected

Table 7: Status and Error Display through Status LED

7 Sensor configuration

7.1 Inclination sensor programming adapter

With the optional inclination sensor programming adapter (starter kit) it is possible to adjust all inclination sensors with CAN/CANopen, current or voltage interface. It consists of a programming adapter that is connected via USB to a PC. The connection with the programming adapter is realized through various, also included adapter cables. The inclination sensor is supplied with power through this. An additional power supply is not necessary.

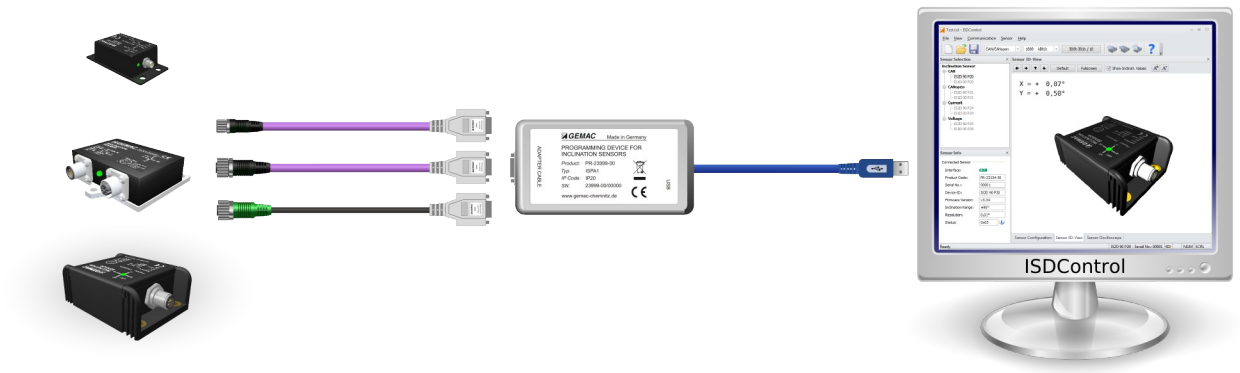


Figure 8: Starter kit

7.2 PC software ISDControl

The parametrization of all possible values is done with the PC software ISDControl, which is included in all starter kits. Each configuration can then be stored in a file.

7.2.1 Configuration of all values

For all inclination sensors, the adjustment of the parameters can be done either numerically or graphically. (refer to Figure 9 and 10).

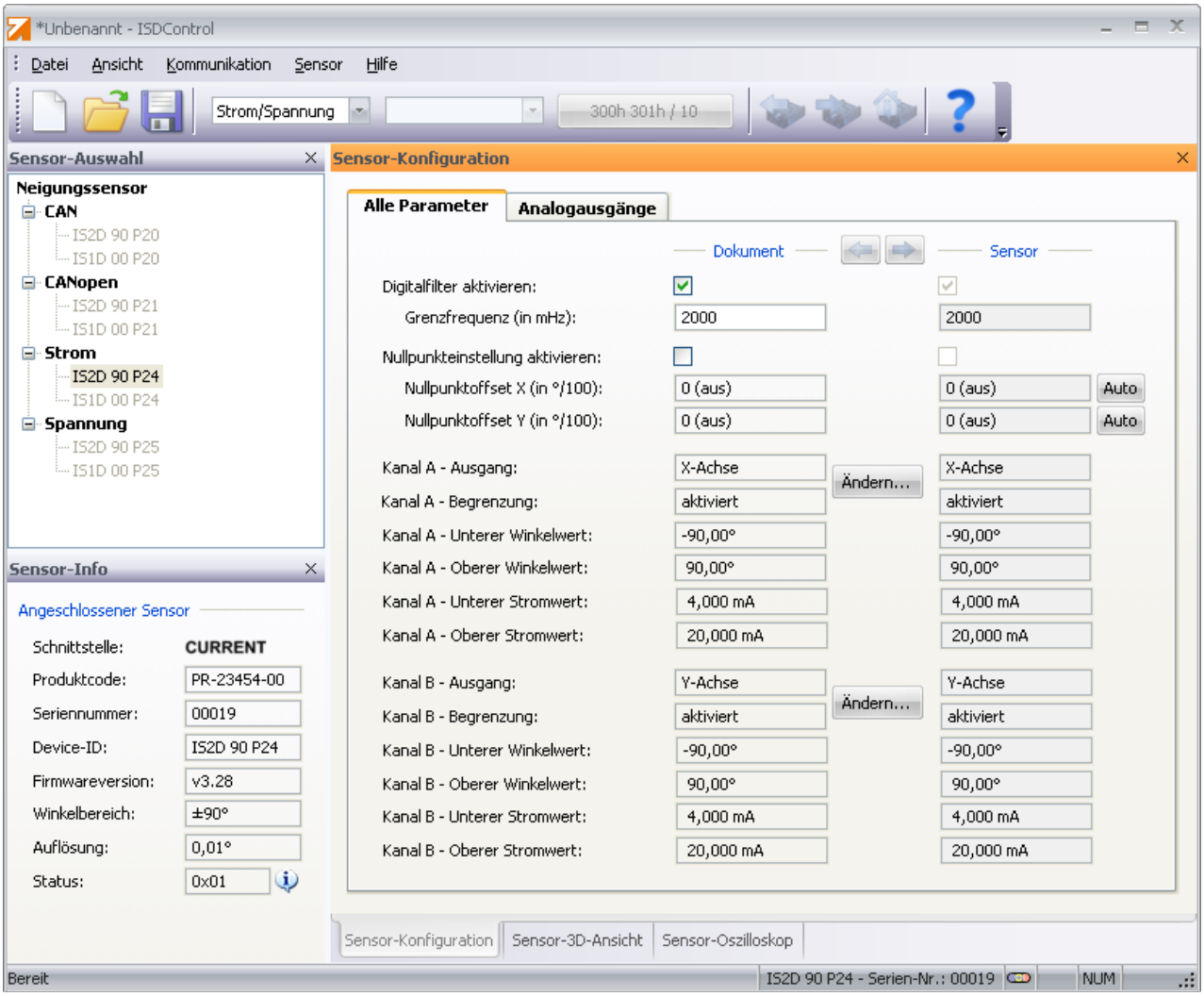


Figure 9: Numerical configuration of the inclination sensor

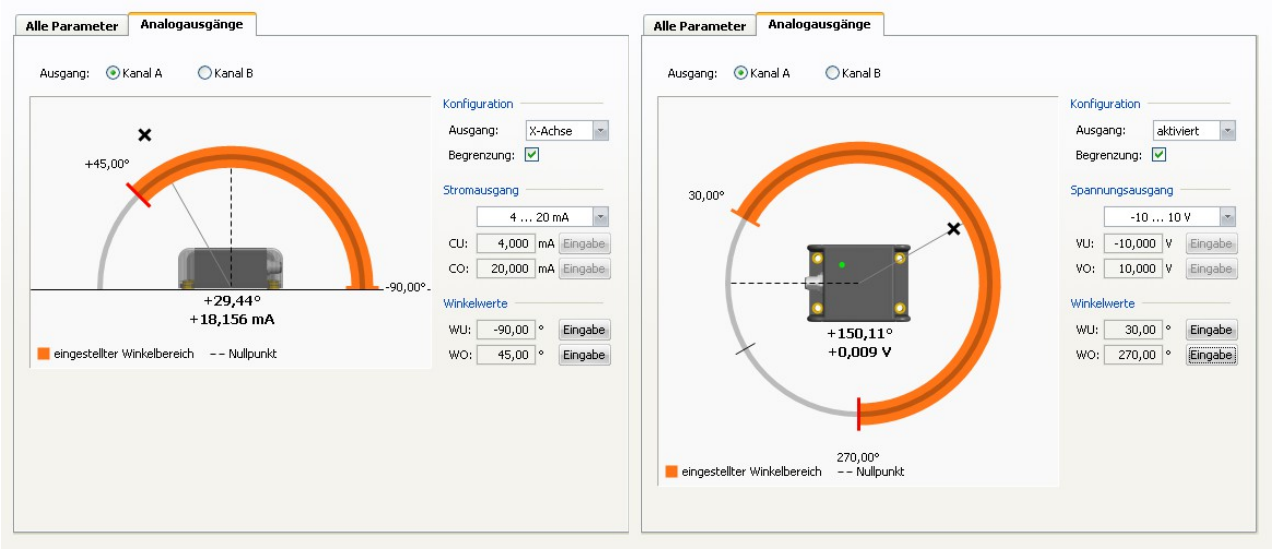


Figure 10: Graphical configuration of the outputs A and B

7.2.2 3D imaging and display of the current angle

By the program integrated 3D view, the position of the sensor in space can be visualized.

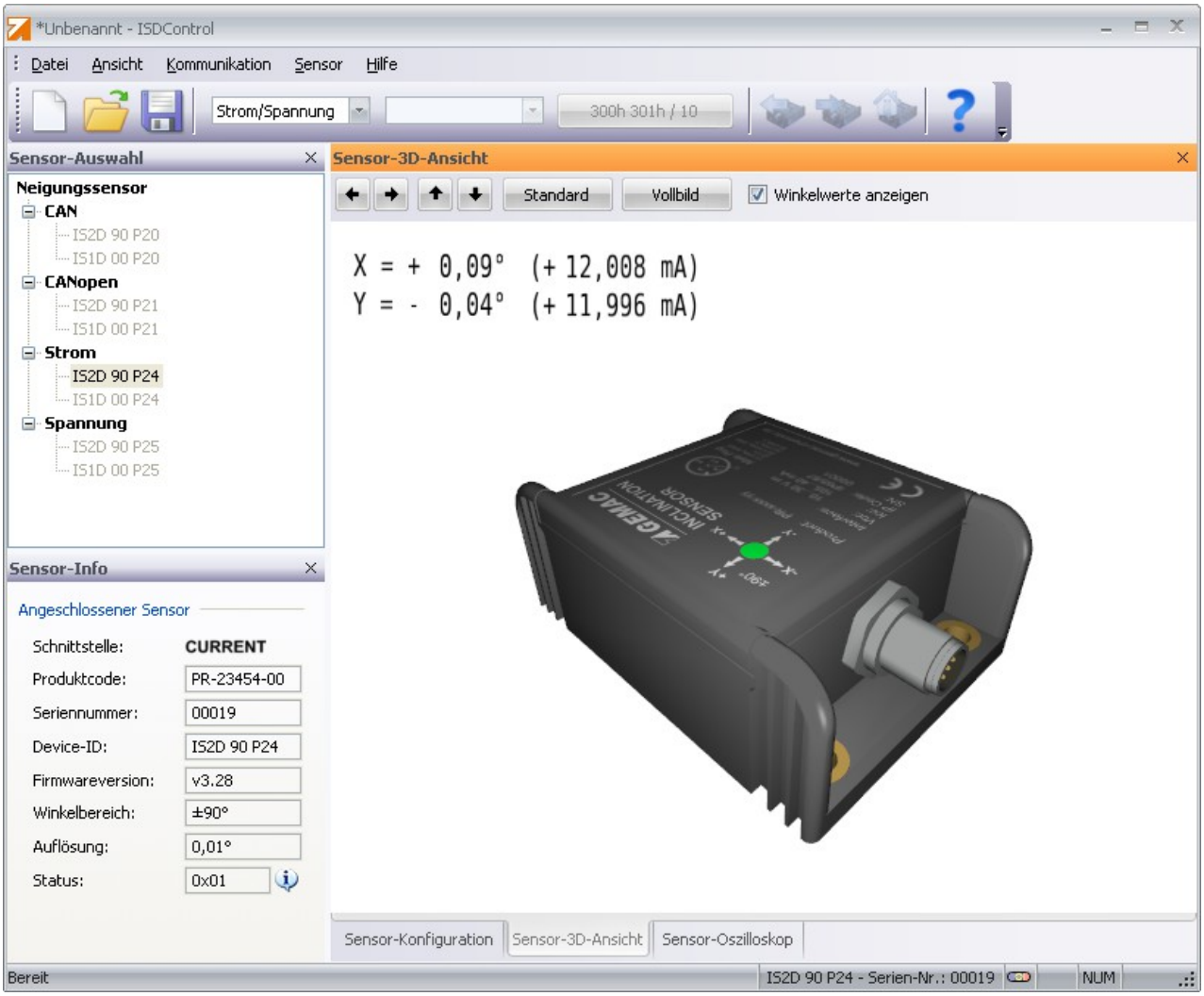


Figure 11: 3D imaging and display of the current angle

7.2.3 Oscilloscope display of the current angle

In the oscilloscope display, the influence of the adjustable digital filter can be controlled directly. Time base of the view, and amplitude and offset can be set analog to the operation of an oscilloscope.

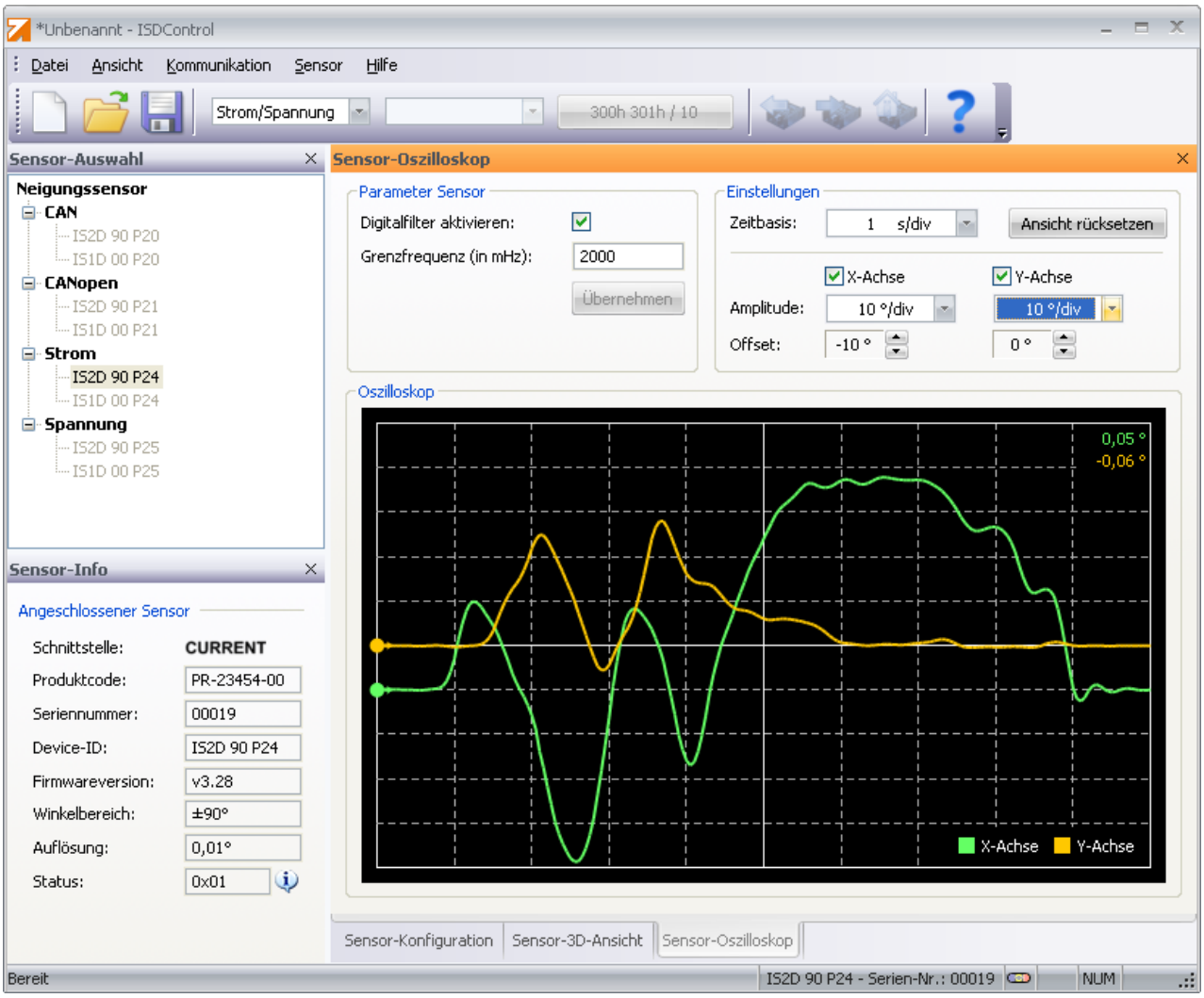


Figure 12: Oscilloscope display of the current angle

8 Ordering Information

Article Number	Product Type	Description/Distinction
PR-23450-00	IS1BP360-I-CL	1-dimensional, 360°, current interface
PR-23454-00	IS2BP090-I-CL	2-dimensional, ±90°, current interface
PR-23550-00	IS1BP360-U-CL	1-dimensional, 360°, voltage interface
PR-23554-00	IS2BP090-U-CL	2-dimensional, ±90°, voltage interface
PR-23998-00	TA1	Teach adapter
PR-23999-01	ISPA1	Inclination sensor programming adapter (Starter kit including programming adapter, cables and PC software)

Table 8: Ordering Information